EFFECTS OF A SINGLE CHEMICAL TREATMENT ON LONG-TERM HARDWOOD DEVELOPMENT IN A YOUNG PINE STAND[1]

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Abstract. The long-term effect of a single chemical treatment for control of understory hardwoods in pine stands has been followed for 16 years. The study began in 1973, when 12 treatments were established in stands of 14-year-old longleaf pine (Pinus alustris Mill.) in southwest Alabama. Four burning treatments, nam e y- G nial burns in winter, spring, and summer plus an unburned check, were each combined with three understory hardwood control treatments: chemical injection of all hardwoods; repeated clearing of woody stems; and no treatment. After 16 years, the chemical treatment combined with fire has not allowed any hardwoods to reach sizes greater than 0.5 inch dbh. Even without fire, hardwood midstory (> 1.5 inches dbh) development after chemical treatment was slow. After 16 years, the hardwood midstory on unburned chemical plots consisted of 47 stems and 1.0 ft^2 basal area/ac, while on unburned check plots there were 340 stems and 15.5 ft^2 basal area/ac. Over the 16 years of observation, seedlings and sprouts (0.5 inch dbh or less) of hardwood tree, species on chemical plots declined, from 5,400 pretreatment to 3,800 stems/ac. These stems on plots without chemical treatment rose from 5,200 to 9,500/ac.

Introduction

Controlling understory hardwoods within young pine stands is expected to provide a number of benefits, including improved growth of overstory pine, reduced fuel loads, easier access, reduced cost of future site or seedbed preparation, and increased grass and other herbaceous cover. Little information is presently available on the long-term effects of herbicide treatments on controlling hardwoods, and especially on slowing future hardwood development.

The effects of chemical eradication of understory hardwoods in a mature loblolly (Pinus taeda L.) and shortleaf (P. echinata Mill.) pine stand were still apparent 23 years later when hardwood basal area was about 6 ft^2/ac in treated stands compared with 36 ft^2/ac in untreated stands (Cain 1985). This difference had not affected the volume growth of overstory pine.

Hardwoods in a 'I-year-old loblolly pine plantation averaged 4 ft^2 basal area/ac when a single herbicide treatment was applied to all hardwood stems. Ten years later, hardwood regrowth averaged 0.6 ft^2 basal area/ac. Without treatment, hardwoods had increased to 41.4 f t ^{2} basal area/ac (Clason 1984). Hard-

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wood control improved the volume growth of these young pine stands, as volume in untreated stands was 30 percent below that in treated stands.

In another study, 11 years of annual chemical and/or mechanical eradication of understory hardwoods in a selectively managed loblolly/shortleaf pine stand failed to have an extended impact on understory hardwoods. Eighteen years after treatments stopped there were as many hardwoods present--about 3500 stems/ac--as there were before eradication efforts began (Cain and Yaussy 1984). Sixty-five percent of these hardwood stems were seedlings; the remainder were saplings. However, there was no comparative information on hardwood development in the absence of any eradication treatments.

A study was initiated in 1973 to determine the effects of several understory hardwood control treatments, including combinations of fire, mechanical, and chemical methods, on understory succession and overstory growth in natural stands of longleaf pine (*P. palustris* Mill.). Effects of treatments on overstory pine growth for the first 10 years of observation have been reported (Boyer 1987). This report is on 16 years of woody understory response to a single chemical hardwood control treatment, both with and without biennial prescribed burning treatments.

Methods

The study was established in 1973 on a sandy upland coastal plain site on the Escambia Experimental Forest[1] in southwest Alabama. Study areas supported well-stocked natural stands of longleaf pine averaging about 700 trees/ac. These stands were 14 years old from seed, 12 years from time of release from the parent overstory.

Three blocks were established, each with twelve 0.4-ac square plots. All plots were thinned to an average 503 dominant-codominant trees/ac. Residual pines in square O.l-ac net plots were marked and numbered, and total height and dbh recorded. Pines averaged 22 ft in height, 3.2 inches in dbh, and 30 ft^2 basal area/ac. Average age 50 site index (Farrar 1981) on study blocks, based on dominant-codominant tree heights at age 30, ranged from 74 to 78 ft.

Woody competition before treatment was estimated by counts of all woody stems on nine 3.1-ft^2 sample plots systematically located in each net plot. Hardwood basal area (at breast height), estimated for each net plot with a lo-factor wedge prism, averaged 3.6 ft^2/ac. The estimate for all small stems (< 1.5 inches dbh) of hardwood tree species, based on sample-plot counts, was 5,300/ac. Eighty-six percent were oaks (*Quercus* sp.), 11 percent dogwood (*Cornus florida* L.), and the remainder persimmon (*Diospyros virginiana* L.) and sassafras [*Sassafras albidum* (Nutt.) Nees]. Woody vegetation other than tree species averaged 102,000 stems/ac, with gallberry

[1] Maintained by the Southern Forest Experiment Station, U.S. Department of Agriculture, in cooperation with the T.R. Miller Mill Co., Brewton, AL.

[Ilex glabra (L.) Gray], blueberries and huckleberries (Vaccinium sp., Gaylussacia sp.), and blackberries (Rubus sp.) making up 91 percent of the total. Vines, rooted in sample plots, averaged 14,400 stems/ac, the majority (72 percent) being honeysuckles (Lonicera sp.), and the balance greenbriars (Smilax sp.).

Twelve treatment combinations were randomly assigned among the 12 plots in each block. Four fire treatments were performed, namely, prescribed fire at 2-year intervals in winter (January-February), spring (April-May), and summer (July-August) plus an unburned check. Each of the four fire treatments was combined with three supplemental treatments as follows: (1) inject all woody stems down to about l-inch groundline diameter with undiluted 2,4-D amine in the spring of 1973; (2) hand clear, by cutting just above groundline, all woody stems more than 4.5-f t tall in the spring of 1973 and at 2-year intervals thereafter, as needed; and (3) leave untreated.

The last fire on all study areas had been a prescribed burn in January 1962. Because of heavy fuel accumulations in the sapling pine stands, all three seasons of burn treatments were initiated with a cool winter prescribed fire in January 1974.

Plots were first reexamined in the winter of 1980, after seven growing seasons. At this time, all net-plot hardwoods in the Z-inch and larger dbh classes (> 1.5 inches dbh) were inventoried by species, and the dbh was recorded. In the fall of 1980 smaller woody vegetation was again sampled on the nine subplots within each net plot. The number of stems, by species, was recorded in two groups: those less than and those above 0.5 inch in diameter at 6 inches above groundline, up to 1.5 inches in dbh. All plots were similarly remeasured in the fall and winter of 1982-1983, 1985-1986, and 1988-1989. During the last two remeasurements, all hardwoods in the 1-inch dbh class were included in the entire net-plot inventory and dropped from the subplot count, which then included only woody stems 0.5 inches or less in dbh.

Results

Hardwood Midstory

Development of midstory hardwoods (> 1.5 inches dbh) was allowed to proceed on all treatments except the mechanical, where repeated handclearing kept. all stems small. Three hardwoods (2.0-2.7 inches dbh) surviving the chemical treatment were still present on summer burn plots in 1980, but only one remained in subsequent examinations. The density of the dominant pine overstory increased from an average 30 ft^2 basal area/ac in 1973 to 97 ft^2/ac in 1989.

Hardwood ingrowth on chemically treated plots has been entirely excluded by all prescribed fire treatments. Even without burning, there was no hardwood ingrowth during the first 10 years after chemical treatment. Sixteen years after treatment there were only 47 stems and 1.0 f t^2 basal area/ac on unburned chemical plots (Table 1). Of these, tree species made up 30 stems and arborescent shrubs 17. All of the stems were in the 2-inch dbh class.

Considering only plots without chemical or mechanical hardwood control treatments from 1980 to 1989, the density and numbers of midstory hardwoods increased on both unburned and winter-burned plots and declined on spring- and summer-burned plots (Table 1). By 1989 there were 220 stems and 10.4 f t ² basal area/ac on winter-burned plots; 340 stems and 15.5 f t ² basal area/ac on unburned plots.

Table 1. Effect of fire and chemical treatment on midstory hardwoods (> 1.5 inches in dbh).

Treatments	Year			
	1980	1983	1986	1989
	(stems/ac)			
Winter burn				
Chemical	**0**	**0**	**0**	**0**
None	190	237	223	220
Spring burn				
Chemical	**0**	**0**	**0**	0
None	153	113	50	7
Summerburn				
Chemical	**10**	**3**	3	3
None	90	97	77	43
No burn				
Chemical	**0**	**0**	30	47
None	287	307	317	340

Midstory Threshold

The immediate source for recruitment into the midstory is voody vegetation in the l-inch dbh class (0.6-l .5 inches in dbh). This class vas tallied *on* entire net plots in both 1986 and 1989 (Table 2). As vith larger stems, the chemical treatment plus burning have prevented any recruitment into the l-inch dbh class. Without chemical treatment, only the spring burn prevented any recruitment into this size class. In the absence of fire, however, woody stems in the l-inch dbh class on chemical plots approached the number on untreated plots in 1986 and exceeded the number on untreated plots in 1989. Woody stems in this size class actually declined on untreated plots between 1986 and 1989, possibly because of competition from an already well-established hardwood midstory that does not yet exist on chemical plots.

A species breakdown of woody stems in the 1 inch d.b.h. class in 1989 revealed that, on unburned chemical plots, only 36 percent of the stems were tree species, while 64 percent were arborescent shrubs (Table 3). The

reverse occurred on unburned check plots, where 80 percent of the stems were tree species and only 20 percent were arborescent shrubs.

Table 2. Effect of fire and chemical treatments on woody stems in the l-inch dbh class.

Year	Treatment	Season of burn: Winter	Spring	Summer	No burn	Average
		(stems/ac)				
1986	Chemical	0	0	0	220	55
	None	140	0	60	317	129
1989	Chemical	0	0	0	343	86
	None	63	0	10	270	86

Table 3. Effect of fire and chemical treatments on hardwood trees and shrubs in the l-inch dbh class in 1989.

Treatment	Season of burn: Winter	Spring	Summer	No burn	Average
	(stems/ac)				
	Tree Species				
Chemical	0	0	0	123	31
None	63	0	10	217	73
	Arborescent Shrubs				
Chemical	0	0	0	220	55
None	0	0	0	53	13

The impact of the chemical treatment is still apparent after 16 years., with fewer tree species than shrubs in the l-inch dbh class. Without chemical treatment, this size class is dominated by tree species. Shrubs in the l-inch dbh class were found only on unburned plots.

Hardwood Regeneration

All woody stems below the l-inch dbh class were tallied on sample plots to obtain an estimate of the number of stems by species or species groups.

These comparisons include all three supplemental treatments, because the mechanical treatment only kept plants small and did not eliminate them. Tree species composed only a fraction of the total woody stems on the forest floor. Over the five examinations, from establishment to 1989, the average number of tree stems on all study plots ranged from 5,300 to 12,900/ac. At the same time, shrubs and other woody vegetation (excluding vines) ranged from 58,000 to 208,000 stems/ac.

Tree **species.** Hardwood tree regeneration was consistently less on chemical plots than on all other plots (Fig. 1). So far, none of the burning treatments have affected regeneration. Plots assigned to the chemical treatment initially averaged 5,400 compared with 5,200 stems/ac for all other plots. After treatment, the difference reached a peak in 1983, when chemical plots averaged 4,100 and all others averaged 17,400 stems/ac. By 1989, chemical plots averaged 3,800 while all other plots had 9,500 stems/ac. The decline in the number of stems after 1983 may be due in part to increasing density of the pine overstory and to several growing seasons that were drier than normal. The 1986 examination occurred at the end of a growing season with both spring and summer fires. Odd year examinations followed a full growing season without fire.

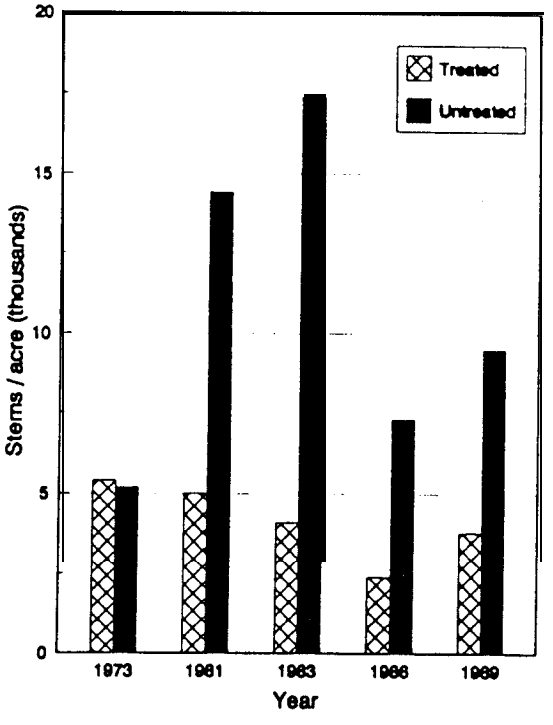

Figure 1. Hardwood tree regeneration (< 0.6 inch dbh) on plots with and without chemical treatment.

Data for the 1981 and 1983 examinations include as regeneration all stems 1.5 inches or less in dbh, while data for the 1986 and 1989 examinations include only stems 0.5 inch or less in dbh. However, numbers in the l-inch dbh class, averaging less than 100/ac by 1989 (Table 3), were too few to affect values given for regeneration in 1981 and 1983.

Sixty-three percent of the hardwood tree regeneration on chemical plots was composed of three species of oak, primarily post oak (Q. stellata Wangenh.). Dogwood accounted for 25 percent, and three other species for 12 percent of the regeneration. Five oak species made up 75 percent, and dogwood composed 19 percent of the regeneration on all plots without the chemical treatment.

Non-tree species. By far the largest number of woody stems on the forest floor were not tree species but shrubs, vines, and other perennial woody vegetation.

The chemical treatment has not significantly (0.05 level) affected numbers of stems of this woody vegetation in any of the four remeasurements since the study began.

Woody vegetation (excluding vines) amounted to 102,000 stems/ac in 1973 and 112,000 stems/ac in 1989. In 1989, chemical plots averaged 123,000 stems/ac and all other plots averaged 106,000 stems/ac.

Vines averaged 21,000 stems/ac in 1989. Overall, yellow jessamine [Gelsemium sempervirens (L.) Ait. f.], greenbriar, and honeysuckle made up 92 percent of all vines (the latter found only on unburned plots).

Discussion1 And Conclusions

The results of this study indicate that a single chemical injection treatment of hardwoods in a young pine stand on a coastal plain site, both with and without periodic prescribed fire, may have a major impact on subsequent long-term development and structure of understory hardwoods. The treatment has resulted, even after 16 years, in sharp reductions in the numbers of stems of hardwood tree species in all size classes, from midstory to regeneration on the forest floor.

Chemical treatment of hardwood tree stems in a pine stand, followed by periodic prescribed fire at any season, can prevent hardwood encroachment into the midstory. In the study reported here, the chemical treatment combined with biennial prescribed fires has entirely prevented hardwood ingrowth into size classes greater than 0.5 inch in dbh.

Even in the absence of fire, hardwood midstory development after chemical treatment is slow. For the first 10 years no hardwoods grew into the midstory (> 1.5 inches dbh). Even after 16 years there were only 47 midstory stems/ac, none of which exceeded 2.5 inches in dbh. All stems of this size are susceptible to top-kill by a prescribed fire and are likely to remain so for several years.

In the absence of fire, chemical treatment favors development of arborescent shrubs in lieu of tree species. Since the chemical treatment was confined largely to tree species, a source for both seeds and sprouts had been reduced, and the growing space occupied by other woody vegetation. Over one-third of the midstory stems (> 1.5 inches in dbh) were arborescent shrubs and nearly two-thirds of the stems in the l-inch dbh class were shrubs. However, 80 to 98 percent of all woody stems over 0.5 inch dbh on unburned plots without chemical or mechanical treatment were tree species rather than shrubs.

A single chemical treatment also has a long-term effect on hardwood tree regeneration (≤ 0.5 inch dbh) on the forest floor. Although this regeneration on chemical plots averaged 3,800 stems/ac, compared to 9,500 stems/ac on all other plots, this relatively small number still represents a continuing source of potential recruitment into the midstory whenever conditions become favorable.

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